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THIRD SEMIANNUAL (TYPE II) PROGRESS REPORT FOR NASA OHIO-ERTS DATA USER PROGRAM (JULY-DECEMBER, 1973)

Project Title: Relevance of ERTS-1 to the State of Ohio

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Preface

The objective of the Ohio-ERTS program is to determine how state government can benefit from orbital survey programs such as ERTS-1. The program is multidisciplinary in nature and involves the experimental evaluation of ERTS-1 imagery and data relay capabilities to environmental quality, agriculture and forestry, and geographic (land-use) applications in Ohio. The statewide program involves the cooperation of the Departments of Natural Resources, Health and Public Works, Economic and Community Development (Lead Department), Transportation, the Environmental Protection Agency, and the Ohio State University. Prime technical subcontractor is the Battelle Columbus Laboratories.

During the first year of the project, efforts concentrated on developing an effective multiagency program for collecting, analyzing, and evaluating ERTS-1 data for Ohio; maintaining an active user awareness program; and, extensive demonstration/documentation of the application candidates identified during the preliminary data analysis phase of the project. Major user awareness accomplishments included the completion and distribution of an Ohio-ERTS Data User Handbook and a demonstration product for subsequent utility assessment of the relevance of ERTS data to surface mining activities in Ohio.

Efforts during the third six months of the project have continued to emphasize on-site/ground-truth data collection and increased demonstration/documentation of the land use, surface mining, forestry, and other application candidates identified during the preliminary data analysis phase of the project. User awareness efforts continued with seminars, lab visitations, and preparation of papers.

Efforts during the remaining six months of the project will focus upon the assessment and determination of the relevance of orbital survey ERTS data to Ohio governmental activities and the completion of the final report.

I. INTRODUCTION

This report represents the third semiannual (Type II) report prepared under the Ohio-ERTS Users Contract NAS5-21782. The report summarizes the status and progress of this program from July 1 through December 31, 1973.

Discussion is presented in the same format as used in the bimonthly progress reports and thus treats data collection, data analysis, DCS, and data utility assessment activities. In addition, a section noting significant results during this period is provided along with a miscellaneous section describing other project developments of potential sponsor interest such as press releases, significant correspondence, visits, etc. And finally, selected items prepared during this third semiannual reporting period are contained in the Appendix.

II. DATA COLLECTION

A. ERTS-1 Data

Table 1 correlates dates of ERTS-1 orbital traces over Ohio with the data received. As recorded in Table I, the project has received imagery for only 69 days out of the 112 days that ERTS-1 has flown over Ohio since August 21, 1972. (Imagery acquired during the November and December overflights of Ohio is expected to be received shortly.) Thus, as reported in the two previous semiannual reports, data for approximately one-half of the ERTS-1 Ohio overflights are being received. Table II describes the coverage and quality of the ERTS-1 imagery received according to the orbital traces over Ohio. In addition to the imagery described in these tables, compatible computer tape data have been received for most of these same scenes. Also, some of the multispectral color composites that have been requested for most of the usable ERTS scenes have been received.

However, since all imagery that contains up to 90 percent cloud cover is received, only about 60 percent (110 of 180) of scenes received is useful. This represents a noticeable improvement in cloud conditions over

TABLE I. SUMMARY OF ERTS-1 DATA RECEIVED ON OHIO

Date	Trace 1	2	3	4
1972				
Aug.	21*	22	23	24
Sep.	8	9	10	11
Sep.	26	27	28	29
Oct.	14	15	16	17
Nov.	1	2	3	4
Nov.	19	20	21	22
Dec.	7	8	9	10
Dec.	25	26	27	28
1973				
Jan.	12	13	14	15
Jan./Feb.	30	31	1	2
Feb.	17	18	19	20
Mar.	7	8	9	10
Mar.	25	26	27	28
Apr.	12	13	14	15
Apr./May	30	1	2	3
May	18	19	20	21
Jun.	5	6	7	8
Jun.	23	24	25	26
Jul.	11	12	13	14
Jul./Aug.	29	30	31	1
Aug.	16	17	18	19
Sept.	3	4	5	6
Sept.	21	22	23	24
Oct.	9	10	11	12
Oct.	27	28	29	30
Nov.	14	15	16	17
Dec.	2	3	4	5
Dec.	20	21	22	23

* Underlined dates indicate dates for which data have been received as of December 31, 1973.

TABLE II. COVERAGE AND QUALITY OF ERTS-1 DATA AVAILABLE BY ORBITAL TRACE OVER OHIO

Date	Time	Area	Quality Comments*
		TRACE 1	
8/21/72	15353	Eastern Lake Erie	Very good
8/21/72	15354	Eastern Ohio and Pennsylvania	Very good
8/21/72	15361	SE Ohio and West Virginia	Very good
9/8/72	15355	NE Ohio and Pennsylvania	Very poor
9/8/72	15362	SE Ohio and 90% West Virginia	Poor
9/26/72	15361	SE Ohio and 90% West Virginia	Poor
10/14/72	15354	NE Ohio and Lake Erie	Good
10/14/72	15361	Eastern Ohio and Pennsylvania	Good
10/14/72	15363	SE Ohio and 90% West Virginia	Poor
12/7/72	15362	NE Ohio and Pennsylvania	Very poor
12/7/72	15364	Eastern Ohio	Excellent
12/7/72	15371	SE Ohio and 90% West Virginia	Poor
1/12/73	15355	NE Ohio and Pennsylvania	Good
1/12/73	15362	Eastern Ohio and Pennsylvania	Good
1/12/73	15364	SE Ohio and 90% West Virginia	Good
2/17/73	15362	NE Ohio and Pennsylvania	Excellent
2/17/73	15365	Eastern Ohio, West Virginia, & Pennsylvania	Excellent
2/17/73	15371	SE Ohio and 90% West Virginia	Good
2/17/73	15374	SE Ohio, West Virginia, & Kentucky	Very good
3/7/73	15375	SE Ohio and West Virginia	Fair
3/25/73	15375	SE Ohio and West Virginia	Fair
4/12/73	15364	NE Ohio and Western Lake Erie	Fair
4/30/73	15363	NE Ohio and Western Lake Erie	Fair
5/18/73	15362	NE Ohio and Western Lake Erie	Fair
5/18/73	15365	Eastern Ohio and Pennsylvania	Fair
5/18/73	15371	SE Ohio and West Virginia	Good
5/18/73	15374	SE Ohio, West Virginia, & Kentucky	Good
6/5/73	15361	NE Ohio and Western Lake Erie	Good
6/5/73	15363	Eastern Ohio and Western Pa.	Fair
6/5/73	15370	SE Ohio and West Virginia	Fair
6/5/73	15372	SE Ohio, West Virginia, & Ky.	Fair
6/23/73	15360	NE Ohio and Western Lake Erie	Fair
6/23/73	15365	SE Ohio and West Virginia	Fair
7/29/73	15353	NE Ohio and Western Lake Erie	Poor
7/29/73	15355	Eastern Ohio and Western Pa.	Very poor
7/29/73	15362	SE Ohio and West Virginia	Very poor
7/29/73	15364	SE Ohio, West Virginia, & Ky.	Poor
8/16/73	15351	NE Ohio and Western Lake Erie	Fair
8/16/73	15354	Eastern Ohio and Western Pa.	Poor

* Quality relates to general cloud cover condition over area covered by satellite photography.

TABLE II. (Continued)

Date	Time	Area	Quality Comments*
		TRACE 1 (Continued)	
9/3/73	15350	NE Ohio and Western Lake Erie	Excellent
9/3/73	15352	Eastern Ohio and Western Pa.	Excellent
9/3/73	15355	SE Ohio and West Virginia	Excellent
9/3/73	15361	SE Ohio, West Virginia, and Ky.	Excellent
9/21/73	15343	NE Ohio and Western Lake Erie	Fair
9/21/73	15350	Eastern Ohio and Western Pa.	Fair
10/9/73	15340	NE Ohio and Western Lake Erie	Poor
10/9/73	15343	Eastern Ohio and Western Pa.	Very poor
10/9/73	15345	SE Ohio and West Virginia	Very poor
10/9/73	15352	SE Ohio, West Virginia, & Ky.	Poor
10/27/73	15334	NE Ohio and Western Lake Erie	Fair
10/27/73	15340	Eastern Ohio and Western Pa.	Fair
10/27/73	15343	SE Ohio and West Virginia	Excellent
		TRACE 2	
8/22/72	15405	NE Ohio, Lake Erie, and Canada	Poor
8/22/72	15412	North from Salt Fork Lake	Poor
8/22/72	15414	East of Columbus, North of boot	Poor
8/22/72	15421	South of Ohio River boot	Poor
9/9/72	15411	NE Ohio, Lake Erie, and Canada	Poor
9/9/72	15414	East of Columbus	Poor
9/9/72	15420	SE Ohio and Kentucky	Fair
10/15/72	15413	NE Ohio, Lake Erie, and Canada	Very poor
10/15/72	15415	East of Columbus	Fair
10/15/72	15422	SE Ohio and Kentucky	Fair
11/20/72	15420	NE Ohio, Lake Erie, and Canada	Very poor
1/13/73	15413	NE Ohio, Lake Erie, and Cleveland	Good
1/31/73	15415	NE Ohio, Lake Erie, and Cleveland	Very good
1/31/73	15422	East of Columbus	Very good
1/31/73	15424	SE Ohio and West Virginia	Very good
1/31/73	15431	South from Ohio River boot	Good

* Quality relates to general cloud cover condition over area covered by satellite photography.

TABLE II. (Continued)

Date	Time	Area	Quality Comments*
		TRACE 2 (Continued)	
2/18/73	15421	NE Ohio, Lake Erie, and Cleveland	Very good
2/18/73	15423	East of Columbus	Good
2/18/73	15430	SE Ohio and Kentucky	Good
2/18/73	15432	South from Ohio River boot	Fair
3/8/73	15422	NE Ohio, Lake Erie, & Canada	Excellent
3/8/73	15424	Columbus and Eastern Ohio	Excellent
3/8/73	15431	SE Ohio	Excellent
3/8/73	15433	SE Ohio and Kentucky	Good
4/13/73	15422	NE Ohio, Lake Erie, and Canada	Good
4/13/73	15425	Columbus and Eastern Ohio	Fair
4/13/73	15431	SE Ohio	Poor
4/13/73	15434	SE Ohio and Kentucky	Very poor
5/1/73	15424	NE Ohio, Lake Erie, and Canada	Very poor
5/1/73	15430	Eastern Ohio	Very poor
5/1/73	15433	SE Ohio and Kentucky	Very poor
6/24/73	15414	NE Ohio, Lake Erie, and Canada	Poor
6/24/73	15420	Columbus and Eastern Ohio	Fair
6/24/73	15423	SE Ohio	Very good
6/24/73	15425	SE Ohio and Kentucky	Good
7/12/73	15415	Columbus and Eastern Ohio	Fair
7/12/73	15422	SE Ohio	Excellent
7/12/73	15424	SE Ohio and Kentucky	Excellent
7/30/73	15411	NE Ohio, Lake Erie, and Canada	Poor
7/30/73	15414	Columbus and Eastern Ohio	Fair
7/30/73	15420	SE Ohio	Good
7/30/73	15423	SE Ohio and Kentucky	Fair
8/17/73	15410	NE Ohio, Lake Erie, and Canada	Fair
8/17/73	15412	Columbus and Eastern Ohio	Fair
8/17/73	15415	SE Ohio	Poor
9/4/73	15404	NE Ohio, Lake Erie, and Canada	Excellent
9/4/73	15410	Columbus and Eastern Ohio	Excellent
9/4/73	15413	SE Ohio	Excellent
9/4/73	15415	SE Ohio and Kentucky	Excellent
10/10/73	15394	NE Ohio, Lake Erie, and Canada	Good
10/10/73	15401	Columbus and Eastern Ohio	Fair
10/10/73	15403	SE Ohio	Fair
10/10/73	15410	SE Ohio and Kentucky	Fair

* Quality relates to general cloud cover condition over area covered by satellite photography.

TABLE II. (Continued)

Date	Time	Area	Quality Comments*
		TRACE 3	
9/28/72	15465	Toledo and Detroit	Poor
11/3/72	15473	NW Ohio, Lake Erie, and Toledo	Poor
11/3/72	15480	Columbus, SW Ohio, and East Liberty	Fair
11/3/72	15482	Southern Ohio and Kentucky	Very good
11/21/72	15474	NW Ohio, Lake Erie, and Toledo	Very poor
12/27/72	15480	NW Ohio	Very poor
12/27/72	15482	Southern Ohio and Kentucky	Very poor
1/14/73	15481	Southern Ohio and Kentucky	Good
2/1/73	15480	NW Ohio and Lake Erie	Very poor
2/1/73	15474	NW Ohio	Very poor
2/19/73	15484	Southern Ohio and Kentucky	Fair
3/9/73	15480	NW Ohio, Lake Erie, and Canada	Very poor
3/9/73	15485	SW Ohio	Very poor
3/27/73	15481	NW Ohio, Lake Erie, and Canada	Excellent
3/27/73	15483	Columbus and Western Ohio	Excellent
3/27/73	15490	SW Ohio, Indiana, and Kentucky	Excellent
4/14/73	15480	NW Ohio, Lake Erie, and Canada	Excellent
4/14/73	15483	Columbus and Western Ohio	Excellent
4/14/73	15474	SW Ohio, Indiana, and Kentucky	Excellent
5/2/73	15480	NW Ohio and Lake Erie	Very poor
5/2/73	15482	Western Ohio	Very poor
5/20/73	15475	NW Ohio, Lake Erie, and Michigan	Fair
6/7/73	15474	NW Ohio and Lake Erie	Excellent
6/7/73	15480	Columbus and Western Ohio	Good
6/7/73	15483	SW Ohio, Indiana, and Kentucky	Good
6/25/73	15472	NW Ohio and Lake Erie	Excellent
6/25/73	15475	Columbus and Western Ohio	Excellent
6/25/73	15481	SW Ohio, Indiana and Kentucky	Excellent
7/13/73	15471	NW Ohio and Lake Erie	Excellent
7/13/73	15474	Columbus and Western Ohio	Excellent
7/13/73	15480	SW Ohio, Indiana, and Kentucky	Excellent
8/18/73	15464	NW Ohio and Lake Erie	Good
8/18/73	15471	Columbus and Western Ohio	Good
8/18/73	15473	SW Ohio, Indiana, and Kentucky	Fair

* Quality relates to general cloud cover condition over area covered by satellite photography.

TABLE II. (Continued)

Date	Time	Area	Quality Comments*
		TRACE 3 (Continued)	
9/5/73	15465	Columbus and Western Ohio	Poor
9/5/73	15471	SW Ohio, Indiana, and Kentucky	Poor
9/23/73	15460	NW Ohio and Lake Erie	Excellent
9/23/73	15462	Columbus and Western Ohio	Excellent
9/23/73	15465	SW Ohio, Indiana, and Kentucky	Good
10/11/73	15453	NW Ohio and Lake Erie	Excellent
10/11/73	15455	Columbus and Western Ohio	Excellent
10/11/73	15462	SW Ohio, Indiana, and Kentucky	Excellent
		TRACE 4	
8/24/72	15532	SW Ohio, Indiana, and Kentucky	Very poor
8/24/72	15523	Toledo and area to the West	Poor
10/17/72	15532	Western Ohio and Eastern Indiana	Poor
10/17/72	15535	SW Ohio, Indiana, and Kentucky	Very good
12/28/72	15541	SW Ohio, Indiana, and Kentucky	Very good
1/15/73	15533	Western Ohio and Eastern Indiana	Very poor
2/2/73	15532	Western Ohio and Eastern Indiana	Very poor
2/2/73	15535	SW Ohio, Indiana, and Kentucky	Very poor
3/10/73	15541	Western Ohio and Eastern Indiana	Very poor
3/10/73	15544	SW Ohio, Indiana, and Kentucky	Fair
3/28/73	15535	NW Ohio	Very poor
4/15/73	15544	SW Ohio, Indiana, and Kentucky	Poor
5/3/73	15543	Michigan, Indiana, & NW Ohio	Very poor
5/21/73	15533	Southern Michigan and NW Ohio	Good
5/21/73	15540	Western Ohio and Eastern Indiana	Very good
5/21/73	15542	SW Ohio, Indiana, and Kentucky	Very good
6/8/73	15532	NW Ohio, Michigan, and Indiana	Excellent
6/8/73	15534	Western Ohio and Eastern Indiana	Very good
6/8/73	15541	SW Ohio, Indiana, and Kentucky	Good
7/14/73	15525	NW Ohio, Michigan, and Indiana	Fair
7/14/73	15532	Western Ohio and Eastern Indiana	Fair

* Quality relates to general cloud cover condition over area covered by satellite photography.

TABLE II. (Continued)

Date	Time	Area	Quality Comments*
		TRACE 4 (Continued)	
9/24/73	15514	NW Ohio, Michigan, and Indiana	Very good
9/24/73	15520	Western Ohio and Eastern Indiana	Very good
9/24/73	15523	SW Ohio, Indiana, and Kentucky	Good
10/12/73	15511	NW Ohio, Michigan, and Indiana	Poor
10/12/73	15513	Western Ohio and Eastern Indiana	Poor
10/12/73	15520	SW Ohio, Indiana, and Kentucky	Poor

* Quality relates to general cloud cover condition over area covered by satellite photography.

Ohio since it was reported in the last semiannual report that only about half (52 of 98) of all imagery received at that time was useful. Figure 1 displays the dates and areas for which usable repetitive imagery has been received and Table III shows the availability and quality (relative to cloud cover) of ERTS-1 imagery by study sites received to date. Moreover, it is particularly encouraging to report that imagery of good quality (cloud free) has now been received for the entire State of Ohio for most seasons of the year.

B. Aerial Photography of Ohio-ERTS Study Sites

As part of the continuing acquisition of multispectral aerial photography of the Ohio-ERTS study sites, aircraft underflights of the East Liberty and Wooster study sites were flown on October 25, 1973, using The Ohio Department of Transportation's twin-engine Beechcraft equipped with a 6" Zeiss RMK-A cartographic camera. The flight altitude was 12,000 feet resulting in 9'1/2" x 9-1/2" format photography at a scale of 1:24,000 and Panchromatic film (9-1/2" x 9-1/2") was used in the State's cartographic camera. Similar underflights of these study sites had previously been conducted on August 29, 1972, and June 14, 1973.

No other plans are underway to collect additional multispectral aerial photography of five Ohio-ERTS study sites as part of the current project. However, other sites of interest such as surface-mining areas may be flown sometime during the next six months for other State projects. The time and site selections will be made considering such factors as areas in which timely opportunities exist, data requirements for on-going utility assessment/user awareness programs, and seasonal vegetative cover.

C. Radiometric and Photographic Study Site Ground Surveys

Photographic and radiometric ground-truth surveys of the five Ohio-ERTS study sites have been conducted to obtain spectral data of value in analyzing ERTS imagery. Table IV shows the current status of the ground-truth surveys by study site . Because of delayed delivery of the ISCO strip chart recorder and calibration data for the radiometer, clouds, and, of the

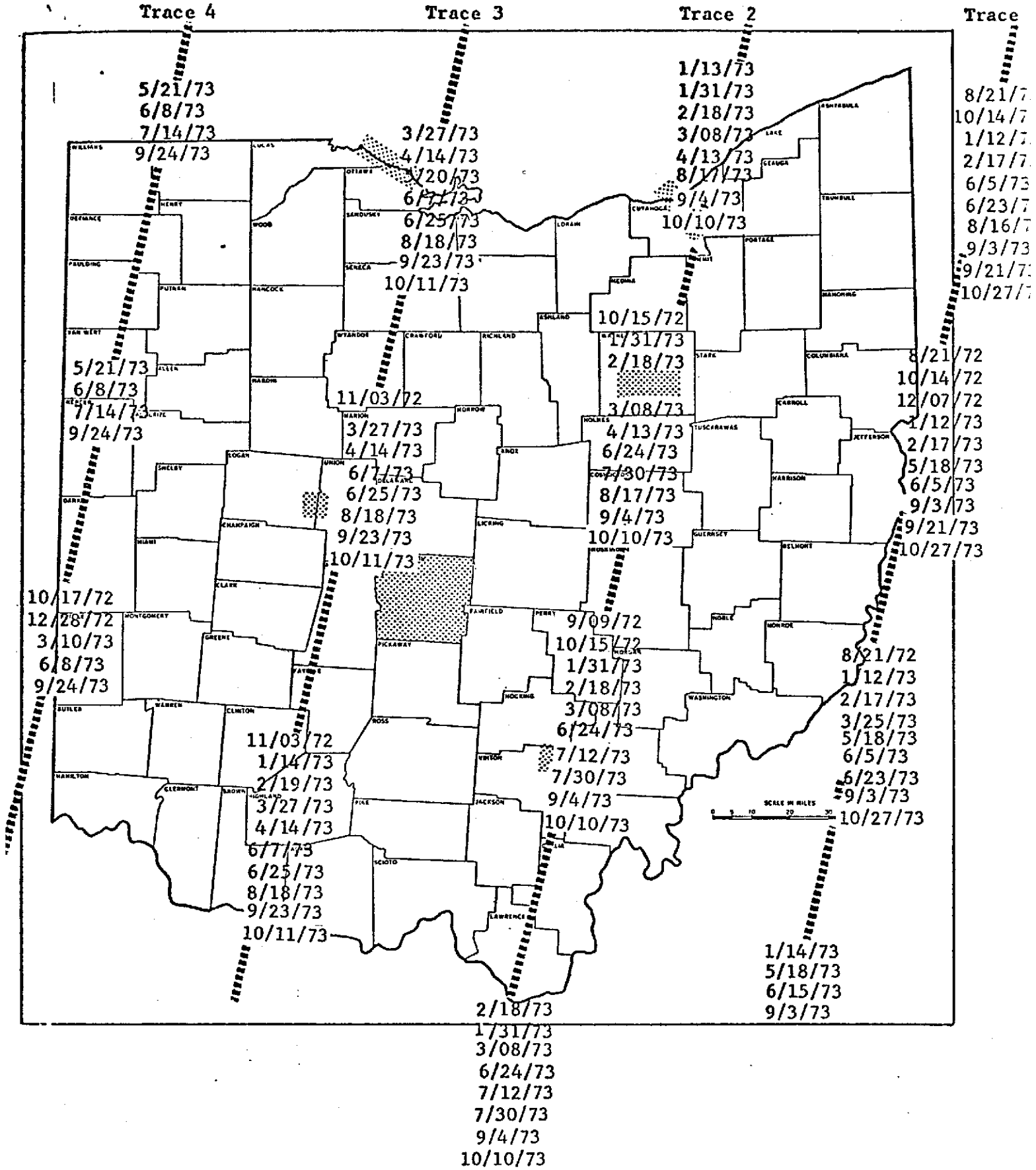

Fig. 1. Status of Usable Repetitive ERTS Imagery for Ohio

TABLE III. STATUS AND QUALITY* OF OHIO-ERTS DATA RECEIVED BY STUDY SITE AS OF DECEMBER 31, 1973

Study Site	Trace	Date	Time	Quality*
Cleveland and Wooster Agricultural Research and Development Center	2	8/22/72	15405	Poor
		9/9/72	15411	Poor
		10/15/72	15413	Very poor
		11/20/72	15420	Very poor
		1/13/73	15413	Good
		1/31/73	15415/15422	Very good
		2/18/73	15421	Very good
		3/8/73	15422	Excellent
		4/13/73	15422/15425	Fair
		5/1/73	15424	Very poor
		6/24/73	15414	Poor
		7/30/73	15411	Poor
		8/17/73	15410	Fair
		9/4/73	15404	Excellent
		10/10/73	15394	Good
East Liberty Transportation Research Center	3	11/3/72	15480	Fair
		11/21/72	15481	Very poor
		12/27/72	15480	Very poor
		2/1/73	15474	Very poor
		3/9/73	15485	Very poor
		3/27/73	15483	Excellent
		4/14/73	15483	Excellent
		5/2/73	15482	Very poor
		6/7/73	15480	Good
		6/25/73	15475	Excellent
		7/13/73	15474	Excellent
		8/18/73	15471	Good
		9/5/73	15465	Poor
		9/23/73	15462	Excellent
		10/11/73	15455	Excellent
Ottawa	3	9/28/72	15465	Poor
		11/3/72	15473	Very good
		11/21/72	15474	Very poor
		2/1/73	15480	Very poor
		3/9/73	15480	Very poor
		3/27/73	15481	Excellent
		4/14/73	15480	Excellent
		5/2/73	15480	Very poor
		5/20/73	15475	Fair
		6/7/73	15474	Excellent
		6/25/73	15472	Excellent
		7/13/73	15471	Excellent
		8/18/73	15464	Good
		9/23/73	15460	Excellent
		10/11/73	15433	Excellent

* Quality relates to cloud cover conditions over study sites.

TABLE III. (Continued)

Study Site	Trace	Date	Time	Quality
Zaleski State Forest	2	8/22/72	15414	Very poor
		9/9/72	15420	Good
		10/15/72	15422	Very good
		1/31/73	15424	Very good
		2/18/73	15430	Good
		3/8/73	15431	Excellent
		4/13/73	15431	Poor
		5/1/73	15433	Very poor
		6/24/73	15423	Very good
		7/12/73	15422	Excellent
		7/30/73	15420	Good
		8/17/73	15415	Poor
		9/4/73	15413	Excellent
		10/10/73	15403	Fair

* Quality relates to cloud cover conditions over study sites.

TABLE IV. STATUS OF OHIO-ERTS STUDY SITE GROUND-TRUTH DATA COLLECTION SURVEYS

Study Site	Air Photos Taken	Photographic and/or Radiometric Ground-Truth Surveys	Areas of Applied Interest
Cleveland	8/29/72 6/14/73	8/15/72 6/14/73 6/15/73 6/21/73 6/22/73	Water quality, Lake Erie sedimentation, shore & beach erosion, urbanized area, surface mining
East Liberty Research Transportation Research Center	8/29/72 6/14/73 10/25/73	8/18/72 9/14/72 6/26/73	Land use/development, agriculture, surface mining
Ottawa Wetlands	8/29/72 6/14/73	8/11/72 6/26/73	Wetlands mapping, flooding, agriculture, Lake Erie shore erosion, sedimentation
Wooster Agricultural Research and Development Center	8/29/72 6/14/73 10/25/73	9/11/72 9/27/72 6/1/73	Agriculture
Zaleski State Forest	8/29/72	8/15/72 10/14/72 10/24/72 7/30/73	Forestry, surface mining

sensitivity of the radiometer to temperatures below 50-60 F, spectroradiometric field work was undertaken only from June through August of this year. The ground-truth surveys undertaken during this reporting period were planned during July and August on days coinciding with ERTS-1 overpasses of Ohio. The two primary sensors utilized to obtain the ground-truth data were an ISCO spectroradiometer with recorder and 35-mm cameras with Ektachrome and infrared color film.

III. DCS/DCP EFFORT

As stated in the July-August Type I progress report, the DCP, having been repaired and returned by the NASA-Wallops Station following apparent lightning damage, was reinstalled on July 2, 1973. It functioned satisfactorily until July 27, when it ceased transmitting. Investigation has revealed that in this case lightning is not a possible cause of the station outage. Thorough checking has shown that sensor signal inputs to the platform are normal, and the cause of the outage is undetermined.

It has been decided to discontinue the use of the platform, rather than shipping it to the NASA-Wallops Station a second time for repair. This decision was made for the following reasons:

(1) The purpose of the platform in the Ohio-ERTS program has been to demonstrate the utility of the ERTS Data Collection System. The use of the platform with the Schneider water quality monitoring equipment has been an ad hoc arrangement which was dictated by the availability of that equipment, and there has been no actual requirement for or use made of the specific data which has been collected.

(2) Although allthe activity planned for the DCP has not occurred (e.g.-interfacing of air quality sensors), the principal objective, as indicated in (1) above, has been accomplished. Experience has been gained in the installation and use of the DCP; a prototype interface device, suitable for future use has been designed, fabricated and utilized; and several months data demonstrating and data processing capabilities of the DCP and DCS, as well as the "traffic handling" capability of the DCS, have been accumulated.

(3) In view of the above, the little, if any, additional value that would accrue to this experiment by its continuance does not warrant the cost of the man-hours that would be involved.

It is planned to prepare an ERTS Utility Demonstration Product describing and summarizing the results of this experiment, for the use of state personnel in evaluating the potential operational utility of the DCS. An evaluation of the usefulness/effective and potential operational possibilities will be included in the final report.

IV. DATA ANALYSIS

A. Data Analysis Laboratory and Equipment Modifications

Further modifications within the laboratory specially constructed for the analysis of remotely sensed data have been made. These modifications, which include the installation of a second TV camera system, the design and fabrication of a 2-way mirror image transfer device, and other lesser photographic modifications, permit more accurate and more rapid overlay of ERTS data onto existing maps and other data sources, readily permit multidate and multi-band analysis, and avoid the requirement for manual drafting and the corresponding errors associated with such drafting methods. Also, during the last six months, preliminary familarization analysis products derived from ERTS-1 computer compatible tapes were provided by BCL's computer center.

B. Data Analysis Plan

No changes have been made in the data analysis plan and according to schedule, the final ERTS data utility assessments by state officials and the final program report will be completed during the next reporting period.

C. Data Analysis Tasks

The major analytical task preformed during this reporting period centered around the development of a procedure to selectively extract one feature from an ERTS photograph by photographic density analysis methods. As shown in Figure 2 a thematic map transparency demonstration product of the major forested areas in southeast Ohio was derived from ERTS data and has been made available to the Ohio Biological Survey to support their concentrated study of the entire Scioto River Basin for the U. S. Army Corps. of Engineers.

Fig. 2. Southeastern Ohio Forestry Transparency Demonstration Product Overlaid Onto Existing 1:250,000 USGS Topographic Map Sheets.

Although the transparency clearly illustrates the significant changes that have occurred in southeastern Ohio's forestry resources since 1966 (when compared to 1:250,000 topographic map) the importance lies in the generation of a new ERTS data product type potentially useful for providing dynamic statewide views of natural and cultural features in single and/or combined formats. For selected study-site areas, the transparency is over 95 percent accurate for mature forested areas in excess of 25 acres, and although the accuracy has not as yet been determined for extrapolated regions, it appears comparable to the USGS 1:24,000 maps and more accurate than the 1:250,000, especially for urbanized areas.

A secondary analytical task undertaken during this reporting period was a one year comparison study of a major strip mining area located in eastern Ohio. This study was undertaken to demonstrate the value of repetitive ERTS-1 imagery in a land-use monitoring capacity. The study site chosen was a controversial area where two of Ohio's major mining shovels had moved into during January, 1973. The comparison was made between a portion of the MSS Band 5 image of 21 August 72 shown in Figure 3 and a portion of the MSS Band 5 image of 3 September 1973 shown in Figure 4. During the one-year period over 400 acres of land in this area were affected by strip mining operations.

V. DATA UTILITY ASSESSMENTS

During the last six months continuing attention was given to assessing the usefulness and relevence of ERTS-1 data to individual programs and interests within various state agencies. Since the beginning of the Ohio-ERTS program 18 months ago, approximately 400 people (over 100 of them during the last six month) have visited the Remote Sensing Applications Laboratory where Battelle and State personnel jointly analyze enhanced ERTS data in regard to a variety of state data requirements. Numerous selected ERTS-1 demonstration products, such as 35-mm slides, color poloroid prints and black and white photographic prints, have been prepared as requested by the various governmental agencies as a result of this program activity.

During the reporting period, major program efforts were focused on the preparation of a specific demonstration product which documents and pictorially displays the application of ERTS data to land use parameters. This report,

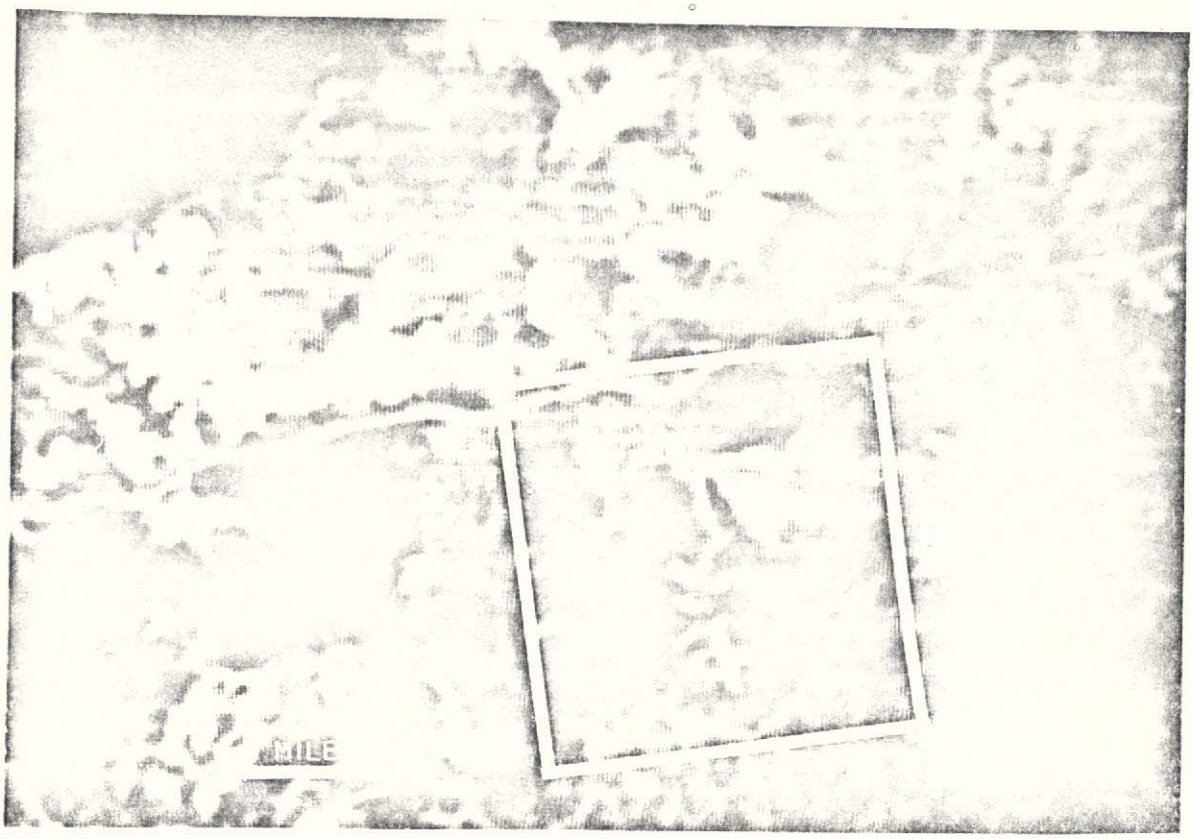

Fig. 3. 21 August 1972 ERTS-1 MSS Band 5 Photo Showing a Heavily Strip Mined Area in Eastern Ohio.

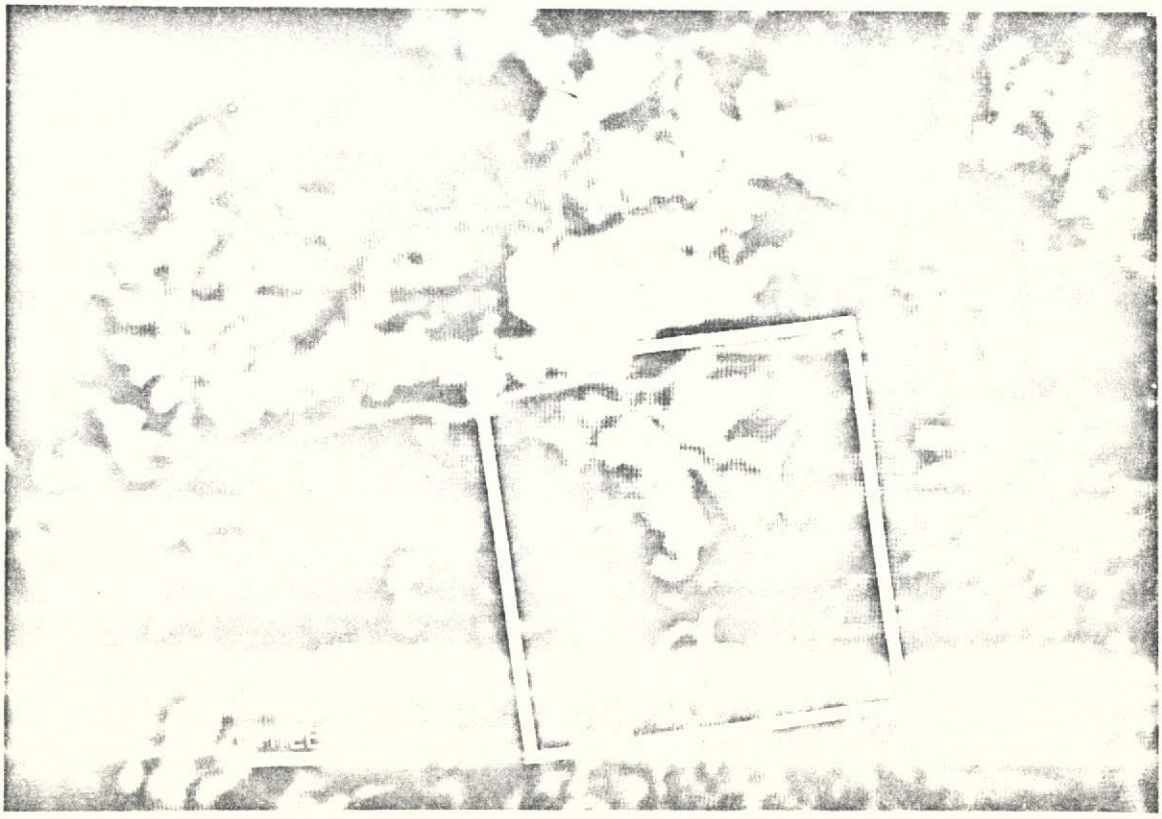

Fig. 4. 3 September 1973 ERTS-1 MSS Band 5 Photo of Same Area Shown in Figure 3 Revealing the Extent of Strip Mining Occurring During a One-Year Period.

entitled "A Demonstration of the Application of Satellite Survey Data: Land Use", is included in the Appendix to this report. In accordance with the Ohio-ERTS project objective of obtaining an assessment of the utility of ERTS data to Ohio, the purpose of this working paper is to document land use applications of ERTS data and is intended for distribution to State officials and planners, initially for information purposes but ultimately for their evaluation of planning and legislative relevance and potential cost-saving benefits.

As a response to almost daily requests from various governmental personnel throughout Ohio to have ERTS-1 capabilities and data use possibilities explained and demonstrated and to assist in making the final state utility assessment, plans are currently being formulated to conduct a two-day workshop in early March to acquaint, familiarize, and update personnel from all state departments and at all governmental levels with the Ohio ERTS program results to date. Planners and officials from state agencies, regional planning organizations, and local planning and policy departments will be invited to review the potential applications of ERTS data established to date and to test the appropriateness of ERTS data to their particular problem-solving needs and interests. In this way, not only will ERTS-1 data utility receive the maximum exposure, but also direct involvement in real-time problem-solving experiments will provide tangible and retainable evidence for planners to consider when integrating the role of ERTS in their future plans and programs. The major anticipated results to be derived from this workshop include an assessment of the revelance of ERTS data to Ohio's management, legislative, and planning activities as well as recommendations for future orbital survey data collection programs.

VI. SIGNIFICANT RESULTS

During the first year of project effort the ability of ERTS imagery to be used for mapping and inventorying strip-mined areas in southeastern Ohio, the potential of using ERTS imagery in water quality and coastal zone management in the Lake Erie region, and the extent that ERTS imagery could contribute to localized (metropolitan/urban), multicounty, and overall state land-use needs were experimentally demonstrated and reported as significant project results.

During this reporting period significant research accomplishments were achieved in the technological development of manual and computerized methods to extract multi-feature information as well as singular feature information from ERTS data as is examplified by the forestry transparency overlay. Fabrication of an image transfer device to superimpose ERTS data onto existing maps and other data sources was also a significant analytical accomplishment.

VII. MISCELLANEOUS

On October 30, 1973, Paul Pincura and Terry Wells of the Ohio Department of Economic and Community Development and Joachim Stephan of Battelle Columbus Laboratories presented a forty-five minute review of the Ohio ERTS Program to a NASA Earth Resources Discipline Panel at Goddard Space Flight Center. As a result of the NASA discipline panel reviews, a summary of the Ohio-ERTS program was presented at the Third ERTS-1 Principal Investigator's Symposium sponsored by Goddard Space Flight Center which was held during the week of December 10 to December 13, 1973 in Washington, D. C. An abstract copy of this paper is attached in the Appendix of this report. During this conference The Honorable Charles A. Mosher of Ohio, Chairman of the U. S. House of Representatives' Committee on Science and Astronautics, was briefed by Paul Pincura of the Ohio Department of Economic and Community as to the relevance of the ERTS program to Ohio.

Also on October 30, 1973, Mr. Clem Meier of the Ohio Department of Natural Resources presented a similar paper written by State of Ohio and Battelle Columbus personnel titled "Application of Remote Sensing to Resource Management at the State Level" at the symposium on Management and Utilization of Remote Sensing Data at Sioux Falls, South Dakota. This paper summarized and pictorally displayed the usefulness of orbital survey data to contemporary resource management problems faced by various departments and agencies of the State government in Ohio. A copy of this paper was attached to July/August Type I progress report.

The Ohio ERTS/Skylab earth resources survey programs will be the subject of a paper which will be presented at the Ninth International Symposium on Remote Sensing of Environment scheduled to be held on April 15-19, 1974 in Ann Arbor, Michigan.

During this reporting period, State and Battelle personnel assisted NASA Lewis officials in formulating a presentation for a Governors' conference on ERTS data use. 35-mm slides of Ohio orbital survey data, data acquisition and analysis equipment, and orbital survey demonstration products were given to NASA Lewis staff for their presentation. Also, on November 1 and 2, State and Battelle personnel hosted and reviewed Ohio's orbital survey programs with Mr. Alexander J. Tuyahov, an associate of the Earth Satellite Corp. (EARTHSAT) and Mr. David W. Stroh, an associate of the Development Research Associates who were conducting a ERTS benefit analysis study for the United States Department of Interior.

At the request of the Cooperative Extension Service of the Ohio State University, Ohio-ERTS project staff members discussed land use applications of ERTS data and the Ohio orbital survey programs at the Cooperation Extension Services' Land Use Planning Workshop held on September 12, 1973 at the Ohio State University. Later that day at Battelle's Remote Sensing Application Laboratory, land use applications of ERTS data were demonstrated to more than thirty of the extension agents participating in the two-day workshop.

Public awareness activities featuring the Ohio ERTS program included a full-page article in the August 20, 1973 edition of the Cleveland Plain Dealer, a demonstration product exhibit/display at the Ohio State Fair (August 23-September 3, 1973) prepared by the Ohio Department of Transportation, and, a demonstration product display at the Farm Science Review held at the Ohio State University on September 18-20, 1973. Photographs of the Ohio State Fair and Farm Science Review displays have been included in (July-August and September-October) Type 1 progress reports. Also, State personnel are currently assembling a ERTS-1 color composite mosaic and several black and white mosaics of the entire state at a scale of 1:250,000. These 5 ft x 6 ft mosaics will be placed in many departments of the State to be utilized for planning, management, and other activities.

Plans for public awareness activities during the next six months include a statewide radio/TV, newspaper and magazine press conference featuring the Ohio orbital survey programs. This press conference will be held in conjunction

with the Ohio-ERTS Data Evaluation Workshop tentatively scheduled to be held in early March, 1974 (See Section V). Also, a letter from Governor John J. Gilligan of Ohio to Mr. Richard Fairbanks, Associate Director of President Nixon's Domestic Council noting the potential relevance of the ERTS Program to Ohio's resource management, planning, and legislative activities and expressing concern of the lack of user federal funding incentives is being prepared.

APPENDIX

SIGNIFICANT APPLICATIONS OF ERTS-1 DATA TO RESOURCE MANAGEMENT ACTIVITIES AT THE STATE LEVEL IN OHIO

by

D. C. Sweet[1], P. G. Pincura[1],
C. J. Meier[2], G. B. Garrett[3], L. Herd[4]
State Government of Ohio

and

G. E. Wukelic, J. G. Stephan, and H. E. Smail
Battelle's Columbus Laboratories

ABSTRACT

According to Dr. David C. Sweet, Director of the Ohio Department of Economic and Community Development and Principal Investigator of the Ohio ERIS and Skylab Programs, "The Ohio satellite effort is a major step towards wise resource management necessary for balanced development in Ohio". Described herein are techniques utilized and the progress made in applying ERTS-1 data to (1) detecting, inventorying, and monitoring surface mining activities, particularly in relation to recently passed strip mine legislation in Ohio; (2) updating current land use maps at various scales for multiagency usage, and (3) solving other real-time problems existing throughout the various Ohio governmental agencies. General conclusions regarding current user views as to the opportunities and limitations of operationally using ERTS-1 data at the state level are also noted.

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(1) Department of Economic and Community Development
(2) Department of Natural Resources
(3) Ohio Environmental Protection Agency
(4) Department of Transportation

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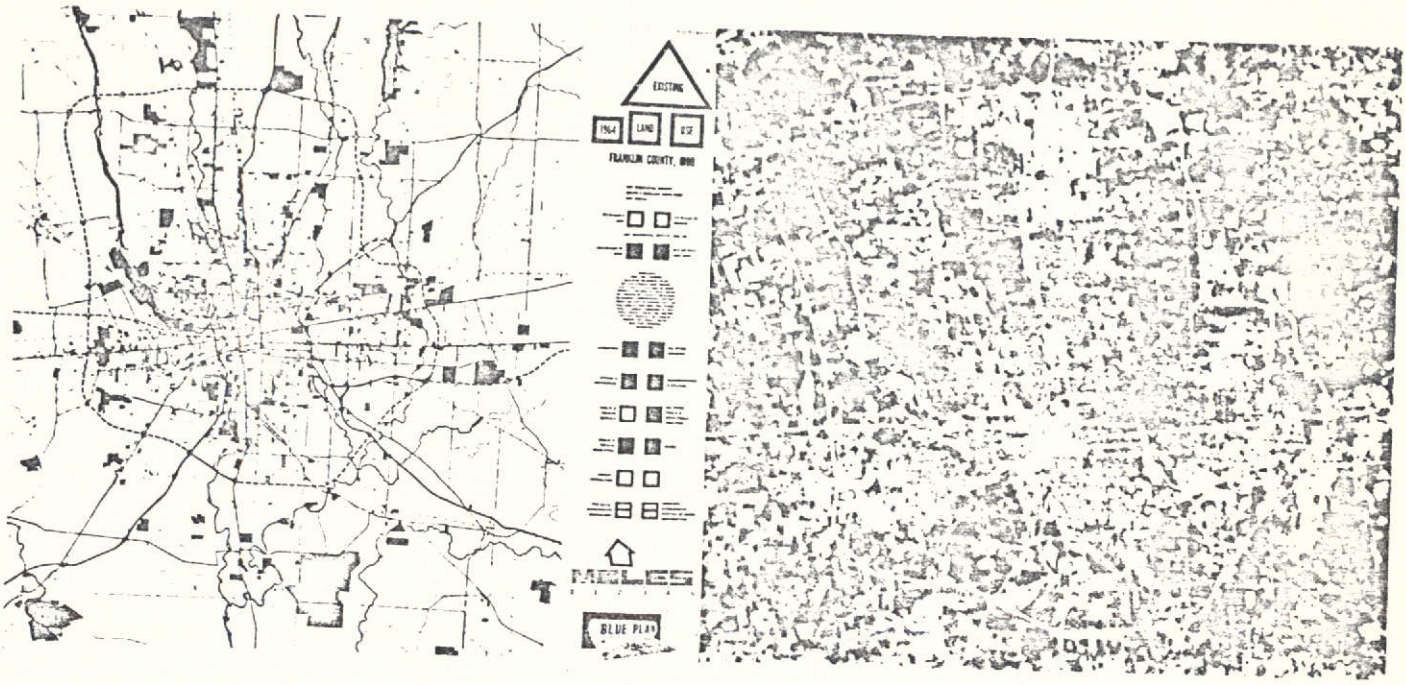
Invited Paper to be Presented at the Third ERTS Symposium, Washington, D. C. December 10-14, 1973.



A DEMONSTRATION OF THE APPLICATION OF ERTS SATELLITE SURVEY DATA: LAND USE

by

George E. Wukelic, Joachim G. Stephan,
Harry E. Smail, Thomas F. Ebbert,
Neil L. Drobny, and Burton S. Middlebrooks

January 15, 1974

NOTICE: This document contains information of a preliminary nature and was prepared primarily to demonstrate ERTS data utility for assessment by State of Ohio planning and resource management personnel. It is subject to revision and correction and therefore does not represent a final report. All photographic reproductions are in black and white and thus resolution and color enhancement fidelity has not been preserved.

SATELLITES FOR OHIO'S FUTURE

"The Ohio satellite effort is a major step toward wise management necessary for balanced development in Ohio".

Dr. David C. Sweet, Director
Ohio Department of Economic and
Community Development

Battelle's Columbus Laboratories is currently working with the State of Ohio to evaluate imagery obtained by NASA's first Earth Resources Technology Satellite (ERTS-1). This satellite passes over Ohio every 18 days, photographing its surface with four "cameras", each time covering roughly a 10,000 square nautical mile area. These photographs are analyzed by Battelle researchers in concert with State of Ohio resource planners and managers to determine what useful environmental, natural, and cultural resource information can be obtained and its significance to the State's on-going land use planning, monitoring, and enforcement activities.

Ohio is one of the few states making a comprehensive, multidisciplined assessment of the state-level utility of orbital survey data. Participating state agencies are:

- Department of Economic and Community Development (Lead Agency)
- Department of Natural Resources
- Environmental Protection Agency
- Department of Transportation
- Public Works
- Department of Health
- The Ohio State University.

The most significant program result to date has been the swiftness with which remote sensing from space has captured the interest and confidence of potential state and local user groups, in spite of their limited experience in the application of remote sensing technology.

This publication is one of several describing and demonstrating the application of orbital survey data to major state-level environmental and resource management problems.

BACKGROUND

Land use, simply the use or uses to which land is put, is determined through a variety of dynamic systems and subsystems operating upon the natural environment in a highly complicated pattern of relationships including the vast apparatus of the private market place for land and housing; the service delivery

systems of local governments that provide water, sewers, roads, and other elements of the infrastructure; the private utilities providing power, fuel, and transportation; the control policies of multiple governments in planning, zoning, assessment and taxation; and, the judicial process relating to civil and property rights. Today, this pattern is becoming even more complicated as environmental quality and energy issues collide.

Ohio, like many other places in the United States and other countries, is beginning to experience the pressures of too little land. Conflicting demands over the use of limited land resources are placing severe strains upon economic, social, and political decision making. Likewise, the lack of physical resource data and a means to analyze the data have hindered the formulation of sound comprehensive policies, the effectiveness of regional planning and management concepts, and the evaluation of individual projects.

With severe pressures being placed upon our finite land resource by the continued growth of the nation's population; expanding urban developments; proliferating transportation systems; large-scale industrial and economic growth; the fragmentation of governmental entities which exercise land use powers; and, the increased size, scale, and impact of both public and private land use decisions; support for a national land use policy in the United States has grown steadily stronger in recent years and indications are that Congress may act early in 1974 on one of the many land use policy bills presently under consideration. One feature common to most of these Congressional bills under consideration is the requirement that to qualify for federal funding the States will have to include "the preparation and continuing revision of a statewide inventory of the land and natural resources of the State" as a part of their land use planning process.

In response to land use pressures, Ohio has recently taken steps to ensure the wise and balanced use of its remaining land resources. In 1972 the Ohio Environmental Protection Agency was established by the General Assembly and became operational. Likewise, new legislation was passed concerning strip mine reclamation and flood plain management legislation is now under consideration by the General Assembly. But Ohio faces increasing multiagency requirements for the periodic preparation of a relatively inexpensive statewide inventory of the land and natural resources of the state for use in general planning, land-use decision making, and legislative processes. The ability to detect, monitor, and inventory the natural and cultural features present on the earth's surface remains as the first prerequisite needed to fulfill this data collection requirement for the State's on-going environmental and resource planning, monitoring, and enforcement activities. Until recently the collection of such terrestrial data had to be accomplished through painstaking ground surveys and/or relatively expensive air surveys. Today, however, with new remote sensing data collection and analytical technologies such as those emerging within the space program (i.e., ERTS and Skylab programs) the urgent and immediate data requirements now have the possibility of being met relatively inexpensively. Moreover, the

repetitive nature of the ERTS-1 satellite as it passes over Ohio every 18 days, has and continues to provide information about significant surface changes which can be monitored on a regular basis. Each ERTS-1 image covers over 10,000 square nautical miles of land at a scale of 1:1,000,000 and upon enlargement scales in excess of 1:24,000 can easily be obtained. Undoubtedly, ERTS imagery offers a means by which land use data acquisition and decision-making processes can be immeasurably improved.

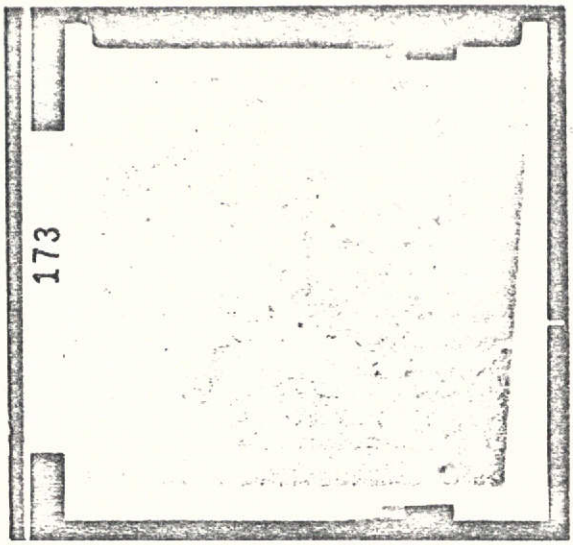
HOW DOES ERTS HELP DISTINGUISH BETWEEN VARIOUS CULTURAL AND NATURAL FEATURES?

ERTS owes its perceptive ability to the fact that every object, living or inanimate, emits, absorbs or reflects light in a highly characteristic way. That is, the earth's natural and cultural features -- water, vegetation, soil, roads, cities -- have unique "signatures" in the realm of multispectral light, and by utilizing the geometric characteristics of such features, these fundamental facts form the foundation of a many faceted project wherein these signatures can be identified and interpreted from data produced through the techniques of remote sensing.

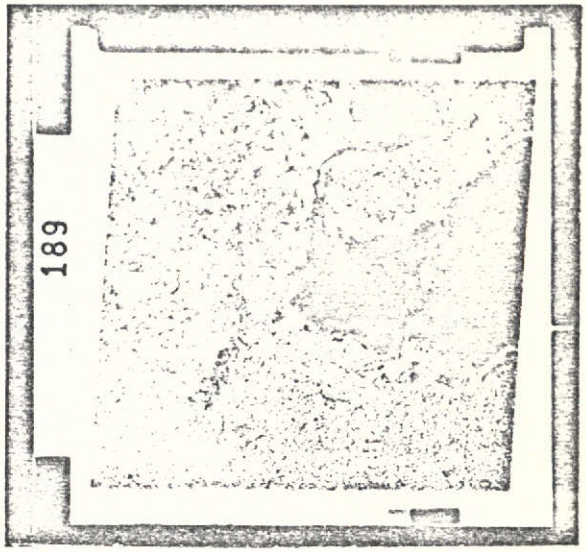
ERTS multiband scanners simultaneously photograph the earth in four different visible and near infrared portions of the electromagnetic spectrum. In Band Number 4 (5,000 to 6,000 Å) cultural features such as urbanized areas, highways, etc., reflect much more solar energy than the surrounding vegetation. Since vegetation reflects sunlight more effectively in Band Number 5 (6,000 to 7,000 Å) and Band Number 6 (7,000 to 8,000 Å) differences in vegetation patterns are readily distinguishable. In Band Number 7 (8,000 to 11,000 Å) bodies of water appear more prominent (very dark) because infrared radiation is readily absorbed in the first few layers of water. ERTS multiband photography thus provides a means for the detection and separation of terrestrial features not possible through broad band photography. Figures 1a-1d illustrate how various land uses in northwestern Ohio are discernible within the various multispectral bands of ERTS-1 imagery. ERTS data are also available in compatible computer tape formats.

LAND USE DATA PRODUCTS

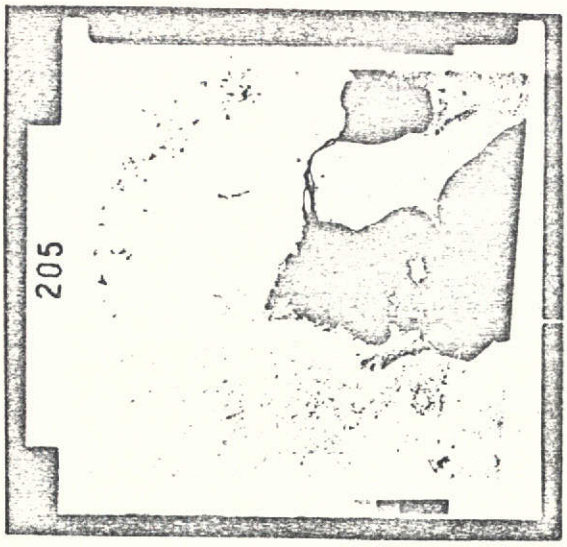
With the capability to identify various natural and cultural features and land use patterns from ERTS imagery well established, various land use data products can be examined. Preliminary evaluation of the usable ERTS-1 imagery existing for all parts of Ohio indicates that ERTS data is more than adequate for periodically mapping and inventorying major surface natural and cultural features at scales of 1:24,000 and smaller and probably at less costs and with better accuracies than with previous techniques. Efforts to date have demonstrated various types of ERTS data analysis techniques and products that can be made available on an operational basis for solving land use problems, for general land use planning, and for meeting the longer range requirements of the pending National Land Use Policy Act.



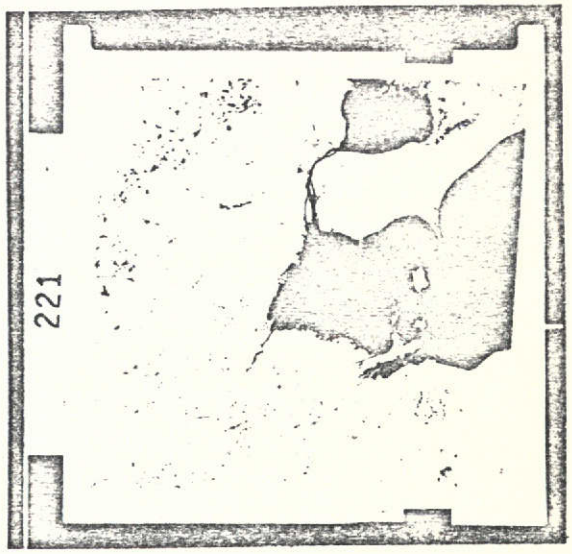
1a. ERTS-1 MSS Band 4 (5,000-6,000 Å) Cultural Features are Prominant.



1b. ERTS-1 MSS Band 5 (6,000-7,000 Å). Cultural and Natural Features are Readily Distinguishable.



1c. ERTS-1 MSS Band 6 (7,000-8,000 Å). Vegetation Patterns are Readily Distinguishable.



1d. ERTS-1 MSS Band 7 (8,000-11,000 Å). Water Bodies are Prominent.

Figure 1. ERTS-1 Multispectral Scanning System (MSS) Images of 7 June 73 of Western Lake Erie, Ohio, and Michigan. Original Scale: 1:1,000,000

Statewide Applications

Since it was not the intent of the Ohio ERTS program to develop a land use classification scheme, a prominent scheme developed and used by the U. S. Geological Survey was adopted. An outline of this classification scheme is shown in Table I, and the level to which each major classification has been evaluated thus far for Ohio-ERTS land use interests is shown on the right side of the table.

A statewide inventory of the land uses in Ohio was the objective of a 1960 Ohio land use study. Utilizing existing 1940 to 1960 data and USGS 1:24,000 topographic maps, this study produced tabulated land use data and generalized 1:250,000 scale land use maps and a 1:500,000 scale land use map shown in Figure 2. The land use maps were then compared to aerial photographs collected from 1958 to 1964 for accuracy determination. This 1960 Ohio land use map was completed over a three-year period at a cost of approximately $110,000, excluding the costs of obtaining the aerial photography. Although the tabulated land use data provided a much needed detailed land use information base, the study and particularly the maps have been found to be inaccurate in numerous areas. Accordingly, a high priority state interest exists relative to the extent, accuracy, and cost of using ERTS data to periodically update such land use information, especially in a much shorter time frame.

This is not to say that there aren't some critical tradeoffs involved by utilizing synoptic orbital surveys rather than data obtained from conventional methods. For example, the 1960 study was done at a scale of 1:24,000 and then combined and generalized to arrive at the 1:250,000 and 1:500,000 maps. Thus, detailed land use work sheets were available as back-ups and for use by planners requiring detailed information. Using the ERTS imagery, this won't be possible except for cases wherein detailed land use maps are made for selected areas of the state. Also, the possibility exists that future operational earth resource survey satellites may have the capability to obtain higher resolution photography for selected "high interest" development areas on a less frequent basis, e.g., once or twice a year coincident with low cloud cover conditions.

Utilizing an image enhancement viewer with a built-in electronic planimetrid device, acreages of various land uses and percent changes over time can be derived. Accuracy of these measurements is dependent upon such parameters as the size of the particular surface feature that is being inventoried and its interrelationships with adjacent surface features.

As illustrated in Figure 3 several black-and-white mosaics and a color mosaic of the entire State of Ohio from 40" x 40" ERTS MSS Band Number 5 images are being assembled by the Department of Transportation and the Department of Economic and Community Development. The mosaics will be placed in many departments of the state for planning and management activities. The significance of the mosaics is, that for the first time, a comprehensive/synoptic overview of Ohio's many diverse environmental, natural, and cultural surface features and their interrelationships can be viewed at once. Also significant is the fact that the ERTS imagery required to complete the mosaics became available in less than a year.

TABLE I. OHIO LAND-USE FEATURES DISCERNIBLE ON ERTS-1 IMAGERY.

USGS Land Use Classification System for Use With Remote Sensor Data*			ERTS, Analysis Status (Includes Levels 1 & 2)
Level I	Level II		
01. Urban and Built-up Land			
	01.	Residential	TBD**
	02.	Commercial and Services	TBD
	03.	Industrial	TBD
	04.	Extractive	Yes
	05.	Transportation, Communications, and Utilities	Yes
	06.	Institutional	TBD
	07.	Strip and Clustered Settlement	Yes
	08.	Mixed	Yes
	09.	Open and Other	Yes
02. Agricultural Land			
	01.	Cropland and Pasture	Yes
	02.	Orchards, Groves, Bush Fruits, Vineyards, and Horticultural Areas	TBD
	03.	Feeding Operations	TBD
	04.	Other	TBD
03. Rangeland			
	01.	Grass	N/A***
	02.	Savannas (Palmetto Prairies)	N/A
	03.	Chaparral	N/A
	04.	Desert Shrub	N/A
04. Forest Land			
	01.	Deciduous	TBD
	02.	Evergreen (Coniferous and Other)	TBD
	03.	Mixed	Yes
05. Water			
	01.	Streams and Waterways	Yes
	02.	Lakes	Yes
	03.	Reservoirs	Yes
	04.	Bays and Estuaries	Yes
	05.	Other (Ice and Snow)	Yes
06. Nonforested Wetland			
	01.	Vegetated	Yes
	02.	Bare	Yes
07. Barren Land			
	01.	Salt Flats	N/A
	02.	Beaches	TBD
	03.	Sand Other Than Beaches	TBD
	04.	Bare Exposed Rock	TBD
	05.	Other	TBD
08. Tundra			
	01.	Tundra	N/A
09. Permanent Snow and Icefields			
	01.	Permanent Snow and Icefields	N/A

* "A Land-Use Classification System for Use With Remote Sensor Data", J. R. Anderson, E. E. Hardy, & J. T. Roach, Geological Survey Circular, 671, Washington, D. C., 1972.

** TBD = To be determined by future analysis.

*** N/A = Classification not applicable to Ohio.

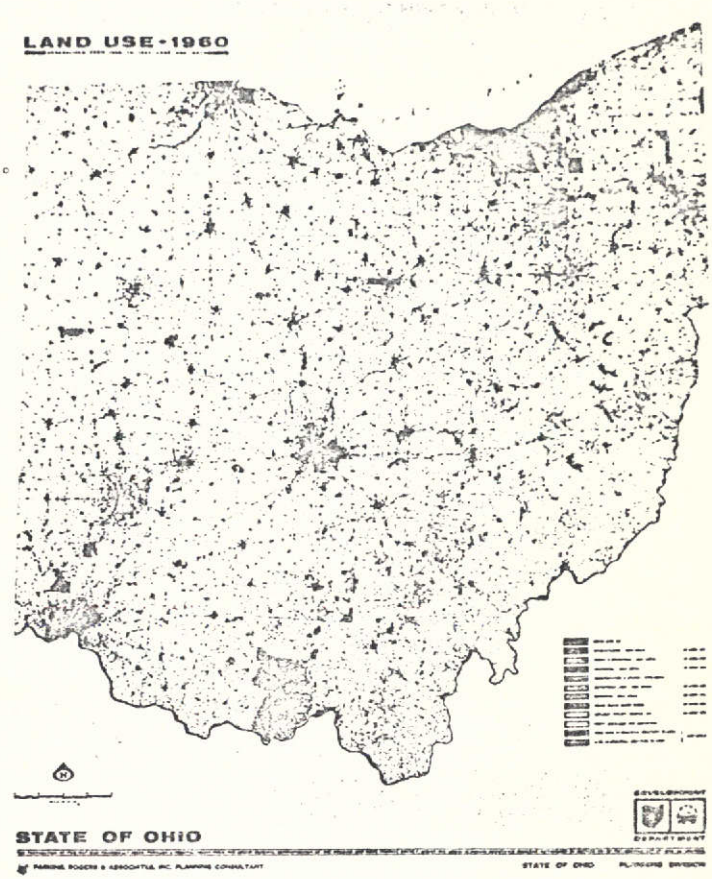


Figure 2. 1960 Generalized Land Use Map. (Original Scale: 1:500,000)

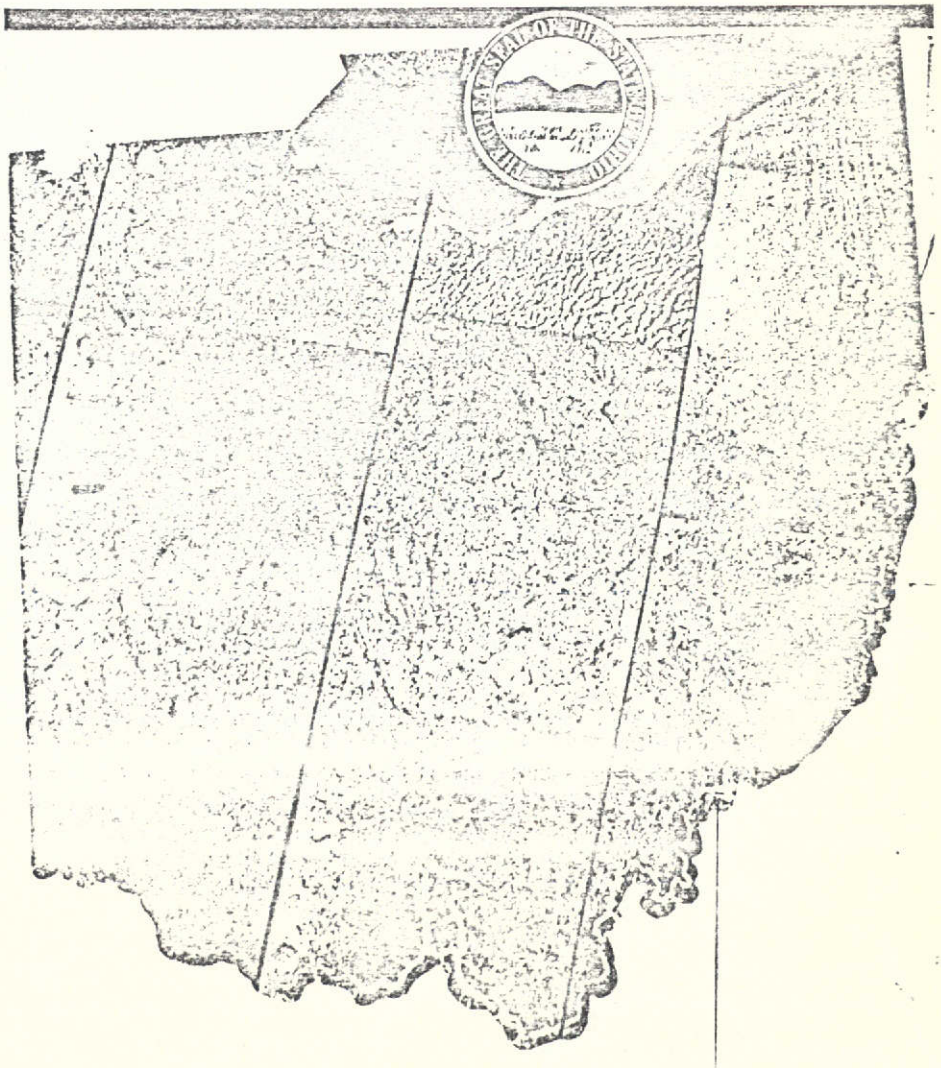


Figure 3. ERTS-1 MSS Band 5 Photomosaic of the State of Ohio. (Original Scale: 1:250,000)

Regional Applications

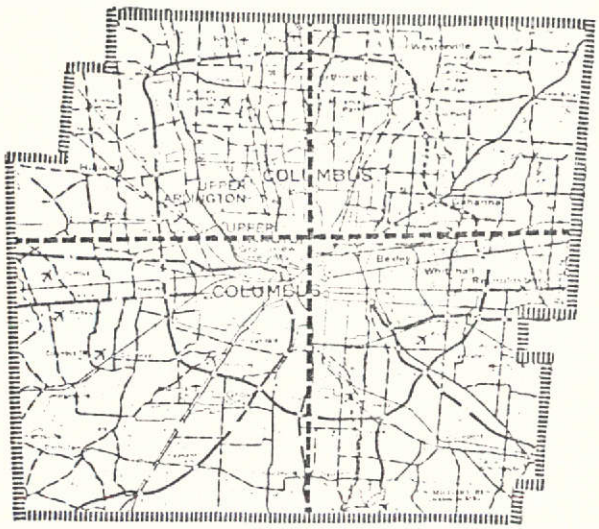
The ability of using ERTS data for discerning various land uses at the regional level in a photographic format is demonstrated by the following series of enlarged and color enhanced ERTS-1 images of the Franklin County/Columbus, Ohio, metropolitan area. The total urbanized area, recent urban growth that has principally occurred over the last 10 years, and the distribution of tree stands, parks, and wood lots present in the approximately 500 square mile Franklin County/ Columbus region is shown in Figures 4a-4d. These photos are enhancements of 15 October 1972 MSS Band 5 ERTS-1 imagery. Figure 5 is an example of an enhanced regional, five-feature, thematic computer printout of the Toledo and northwestern Ohio area compared to the existing Ohio land use map of that area. This computer printout was derived from the ERTS-1 computer compatible tapes of 7 June 1973.

Local Applications

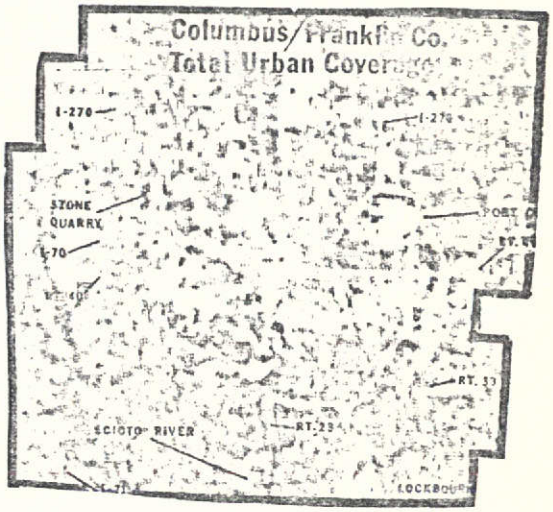
At more of a micro scale the feasibility of using ERTS-1 data to discern land use changes and update land use maps in both computer and photographic formats is illustrated in Figures 6a-6d. At a 1:24,000 scale, ERTS-1 data are compared to aircraft and USGS topographic map data of the Huber Ridge subdivision area in the northeastern sector of the Columbus metropolitan area. This comparison clearly illustrates the degree of image detail and fidelity that may be extracted from ERTS imagery through magnification and electronic enhancement.

Specific Applications

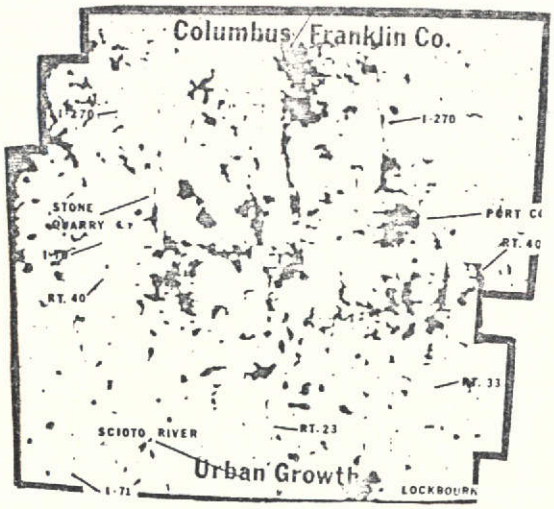
In addition to detecting, inventorying, mapping, and monitoring natural and cultural surface features at state, regional, and local scales; ERTS data can also be used in considerations relative to specialized developments and activities such as nuclear power facilities; transportation facilities; reservoirs, parks and recreational facilities; prime agriculture lands and areas of environmental concern; urban growth and development; and extractive industries such as surface mining. A similar ERTS-1 demonstration publication documenting applications of ERTS-1 imagery to surface mining interests in Ohio has already been published. Figure 7 highlights some of the major land use changes associated with the developments which are occurring in the area where the U. S. Army Corps of Engineers is currently constructing a multipurpose dam on Alum Creek just north of Columbus in Delaware County. Figure 8a provides an example of the technological capability to select a particular surface feature from an ERTS image by density analysis and to produce a corresponding transparent overlay of that feature. In Figure 8b the boxed area of Figure 8a is enlarged and superimposed onto a USGS topographic map sheet to provide a means to access the degree of change in forest cover thathas occurred in the area. Likewise, Figure 8b illustrates the cartographic accuracy obtainable from ERTS data as well as the capability of using ERTS-1 data to update existing maps.



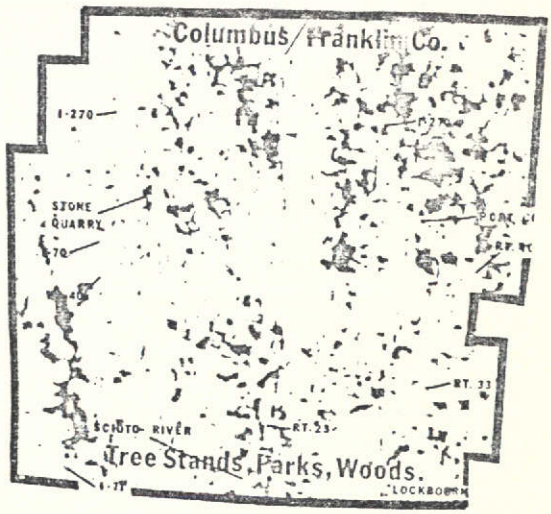
4a. USGS Topographic Map



4b. Total Urban Coverage



4c. Urban Growth Areas



4d. Tree Stands, Parks, Woods

Figure 4. Enhancements of Metropolitan Land-Use Features Discernible on ERTS-1 Photography. (Original Scale: 1:250,000)

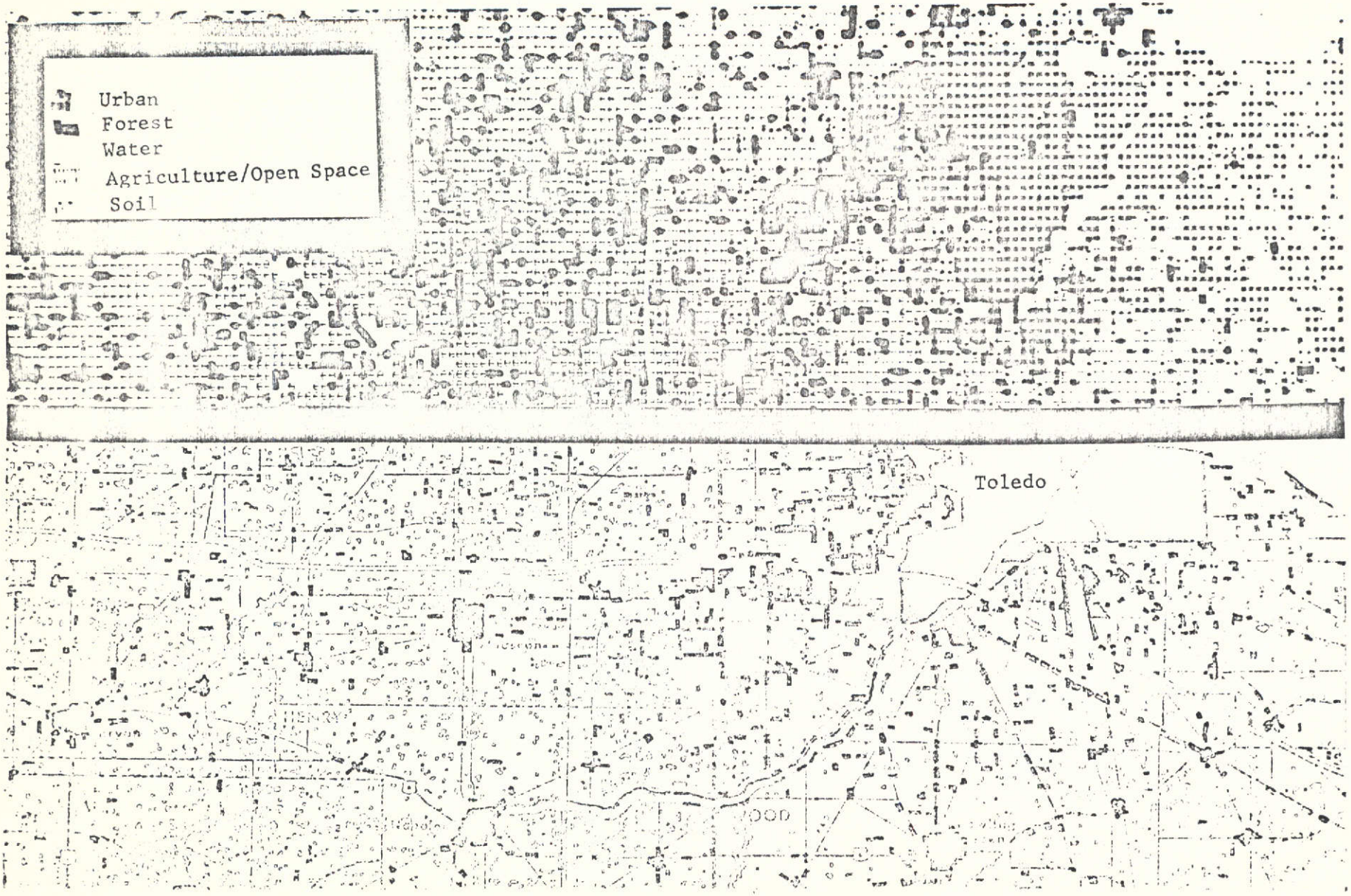
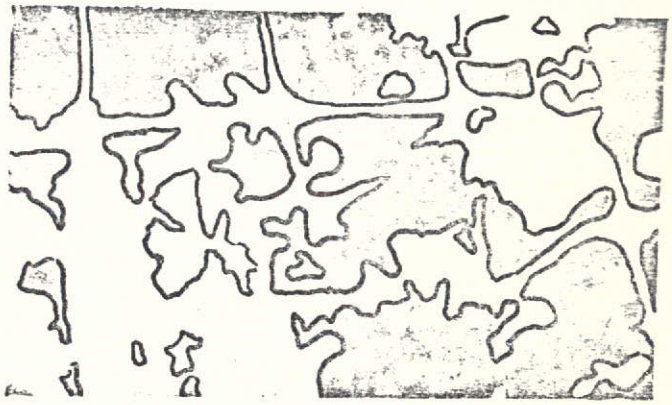


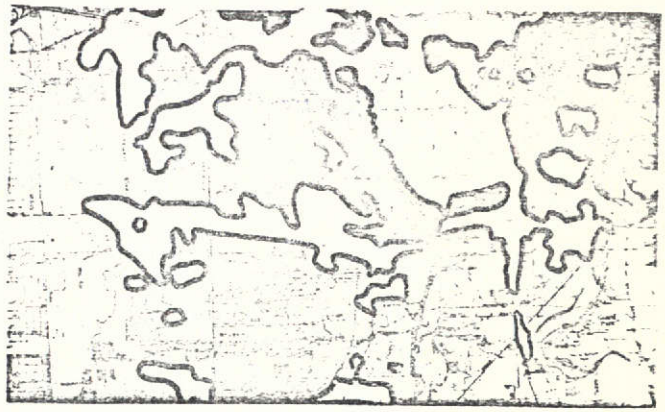
Figure 5. Regional Five-Feature Thematic Computer Printout Derived From the ERTS-1 Compatible Computer Tape of 7 June 1973 of the Toledo and Northwestern Ohio Area Compared to the Existing Ohio Land Use Map of That Area. (Original Scale: 1:250,000)

6a. 1:48,000 Aircraft Index Photo Sheet of April 17, 1972, of a Recently Urbanized Area in Northeastern Columbus, Ohio

6b. An Electronically Magnified Portion of an ERTS-1 MSS Band 5 Photograph of November 3, 1972, of the Area Highlighted to Illustrate New Urban Areas and Major Highways.



6c. Magnified and Color Enhanced Portion of an ERTS-1 MSS Band 5 Photograph of November 3, 1972, Superimposed on a 1964 1:24,000 USGS Topographic Map Sheet of the Area. The Recently Urbanized Areas are Highlighted to Illustrate the Capability of ERTS Imagery to Accurately Identify Land-Use Changes.



6d. An Eight-Character Computer Printout Demonstration Product Derived From the ERTS-1 MSS Band 5 Computer Compatible Tape of November 3, 1972, of the Area.

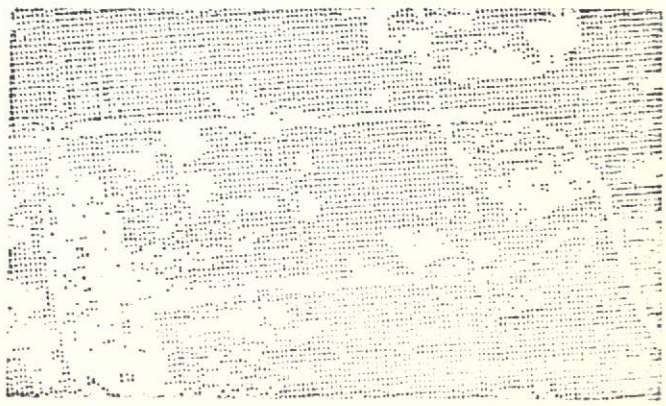


Figure 6. Photographic and Computerized Examples of ERTS-1 Localized Applications.

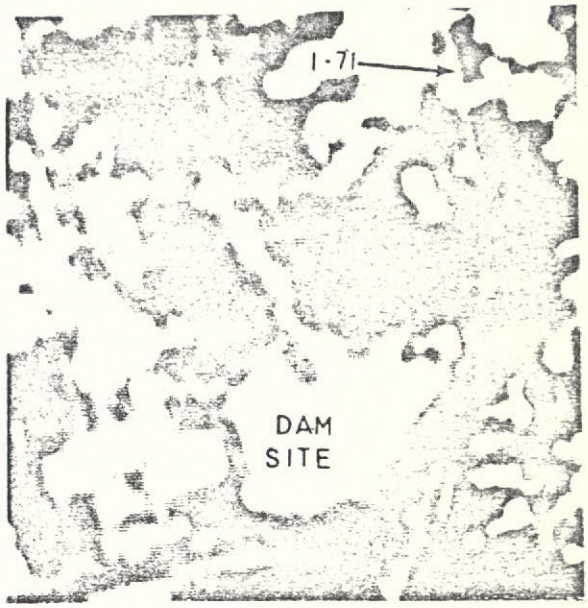


Figure 7. ERTS-1 MSS Band 5 of 13 July 1973 Enhanced to Highlight Land Use Changes Relative to Construction Activities of the Alum Creek Dam in Delaware County, Ohio. (Original Scale: 1:125,000)

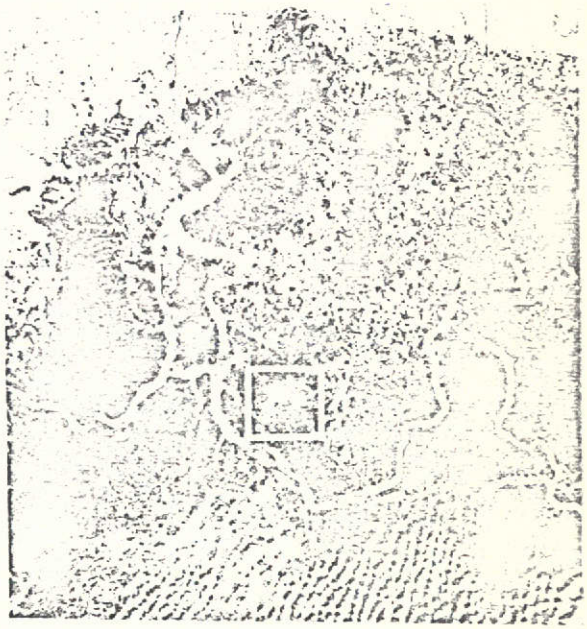


Figure 8a. ERTS-1 Transparency Overlay Demonstration Product Highlighting the Forested Areas in Southern Ohio Which Was Derived From ERTS-1 MSS Band 5 Image of 15 October 1972. (Original Scale: 1:250,000)

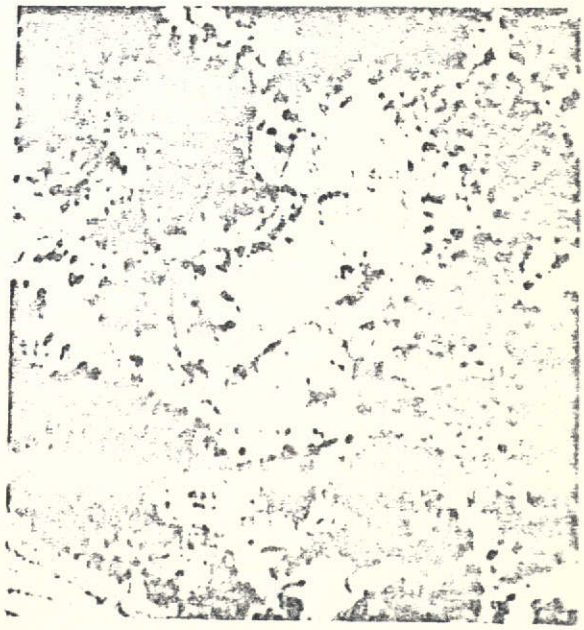


Figure 8b. Enhancement of Boxed-in Area of Figure 8a Which Illustrates Changes in Forested Areas That Have Occurred as Well as Cartographic Accuracies Obtainable From ERTS-1 Data.

Multidate Applications

The following illustrations of the Ohio Transportation Research Center illustrate the capability of ERTS-1 to monitor land use changes over time which is possible because of ERTS' sun-synchronized 18-day repetitive overpasses. With the creation of the Ohio Transportation Research Center near East Liberty, Ohio, the area is undergoing a rapid transition from primarily agriculture uses to a built-up area. As seen by comparing Figures 9a and 9b, ERTS imagery has monitored the construction of the 7-1/2 mile High Speed Test Track and other surrounding land use changes in the area. Likewise, the ability to obtain data at various seasons of the year is extremely valuable in land use information collection activities, especially for vegetation studies. Figures 10a-10d show ERTS-1 MSS Band Number 5 imagery of northeastern Ohio and the Cleveland area in various seasons of the year. It is hoped that ERTS-1 will continue to provide imagery of Ohio areas so that comparisons of longer time spans can be made as development occurs in and around the Research Transportation Center as impounded water accumulates in the Alum Creek Dam, and as land use patterns change in other areas.

RESULTS OF OTHER ERTS-1 LAND USE INVESTIGATIONS

In addition to the ERTS project being undertaken in Ohio, similar land use classification, mapping, and inventorying programs are being conducted in other states. Other ERTS investigators are assessing the utility of ERTS data in relation to soil/geological/landform, vegetation, and thematic maps and inventories, cartographic implications; and flood and other disaster assessments. Demonstration products that have been produced to date include numerous land use maps such as an 11-category land use map for the States of Massachusetts, Connecticut, and Rhode Island; thematic maps identifying areas of environmental concern, prime agriculture lands, and soil, crop, and vegetative maps; and, photomosaic base maps. Successful land use related operational applications of ERTS data include various applications of ERTS data to Land Management Information Systems, computerized classification and statistical extraction of land use information, and environmental impact assessments associated with land use and land use changes in the CARETS (Central Atlantic Regional Ecological Test Site) area.

SIGNIFICANCE OF ERTS DATA TO LAND USE PLANNING, ADMINISTRATIVE, AND LEGISLATIVE APPLICATIONS

ERTS data provide the means for fulfilling the long standing planning professional's quest for synoptic vision, since innumerable implications are afforded planners by an orientation and understanding of the spatial context and contents of the area under evaluation. An integrated view of each land use pattern and the surrounding dynamic land use interrelationships often serve to clarify planning problems and suggest possible solutions. Likewise, as a communication device, ERTS data products display more informatively the data requirements of a given situation, especially in a regional context, and thus aids in bridging the gap between the planner's information base and his perceptions with those of his audiences.

14

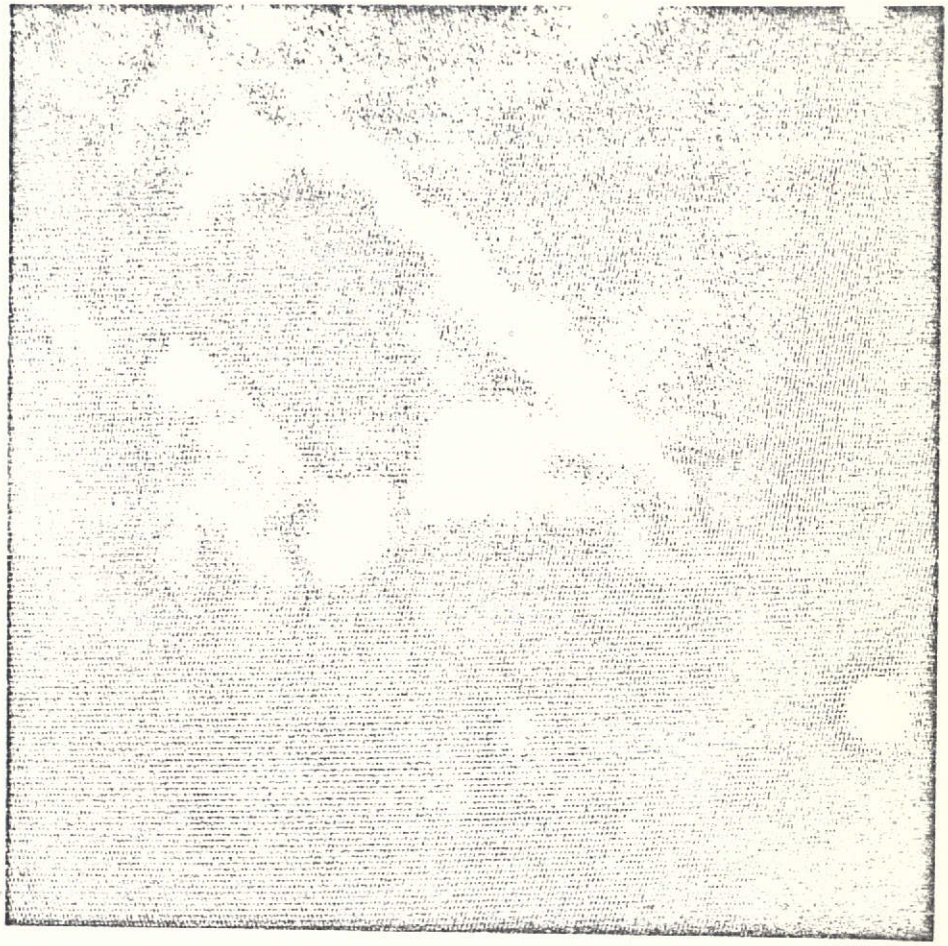


Figure 9a.

ERTS-1 MSS Band 5 of 3 November 1972 Enhanced to Highlight the 7-1/2 Mile High Speed Track of the New Ohio Transportation Research Center Near East Liberty, Ohio. (Original Scale: 1:42,000)

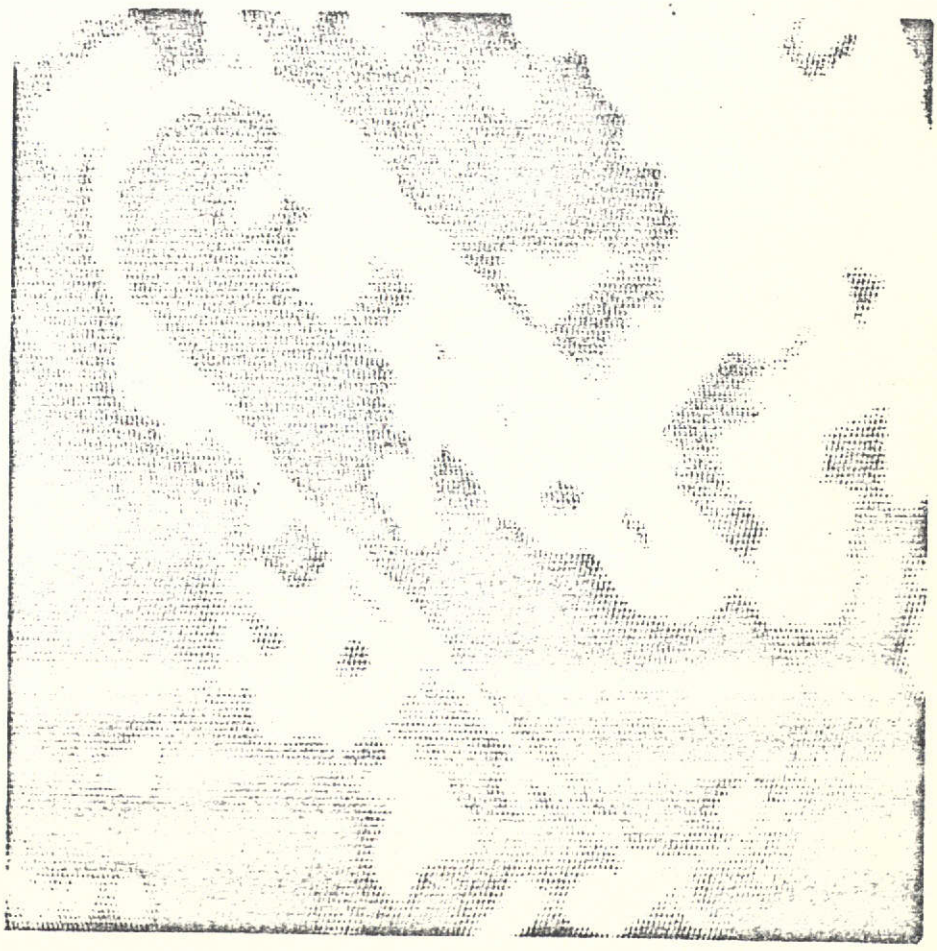
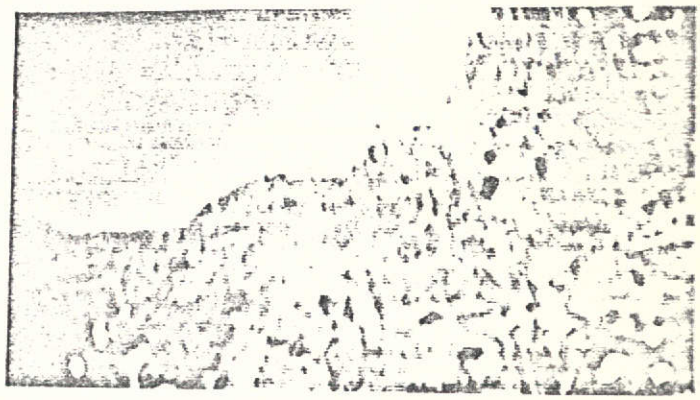


Figure 9b.

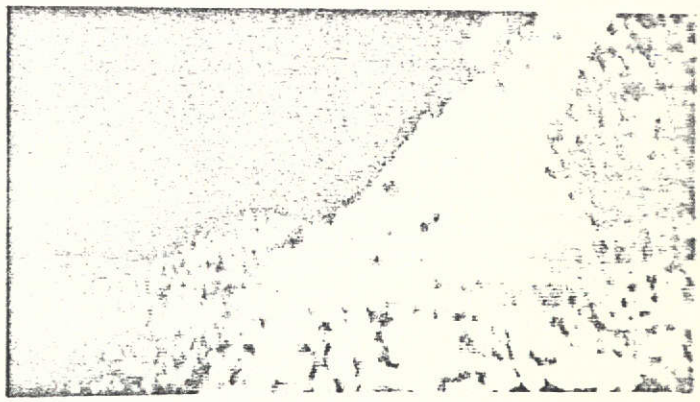
ERTS-1 MSS Band 5 of 13 July 1973 Enhanced to Highlight the 7-1/2 Mile High Speed Track of the New Ohio Transportation Research Center Near East Liberty, Ohio. (Original Scale: 1:42,000)

10a. Winter 18 February 1973
Ice Formations and Water Bodies are Prominent.

10b. Spring 13 April 1973
Major Highway Networks and Sedimentation Patterns in Lake Erie are Easily Seen.



10c. Late Summer 4 September 1973
Agricultural Patterns in the Areas Surrounding Cleveland are Readily Noticeable.



10d. Autumn 10 October 1973
Vegetation Patterns are Readily Distinguishable.

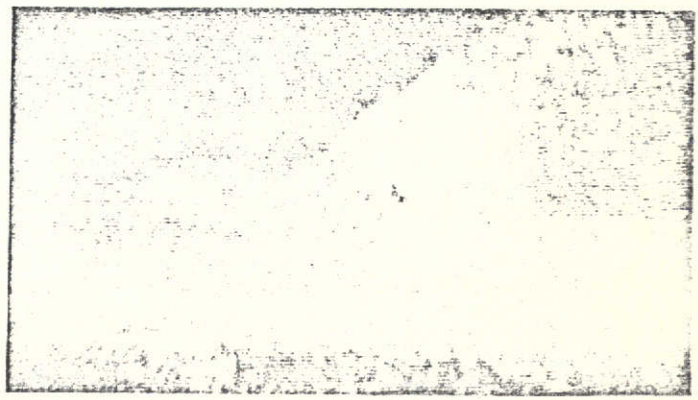


Figure 10. Enlarged Portions of ERTS-1 MSS Band 5 Scenes of Cleveland Area Illustrating the Temperal Benefits Provided by Repetitive ERTS-1 Imagery to Detect and Monitor Seasonal Variations of Terrestrial Features.

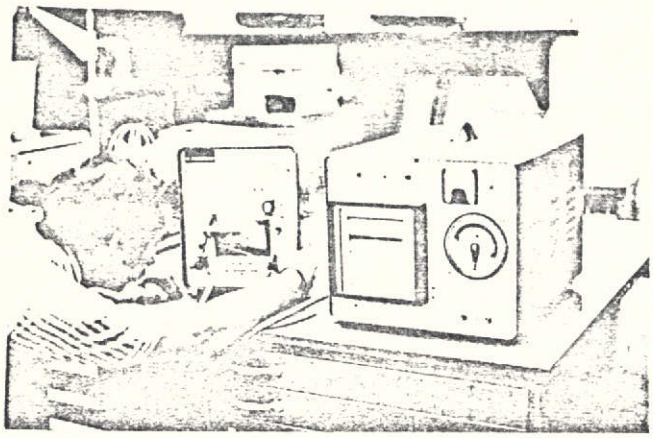
From an administrative viewpoint, ERTS has provided and continues to provide comparable repetitive multispectral data not only for Ohio and the United States, but for most areas of the world on a nearly real-time basis. The dynamic ramifications of interactions of man and nature that are acquired by ERTS in various ready-usable formats can be applied at various desired scales. Such ERTS data characteristics are important for administrative activities such as the implementation of the regionalization program in Ohio. Similarly, such characteristics of ERTS imagery provide an effective mechanism for the enforcement of existing and proposed land use legislation such as construction within floodplain areas.

CONCLUSION

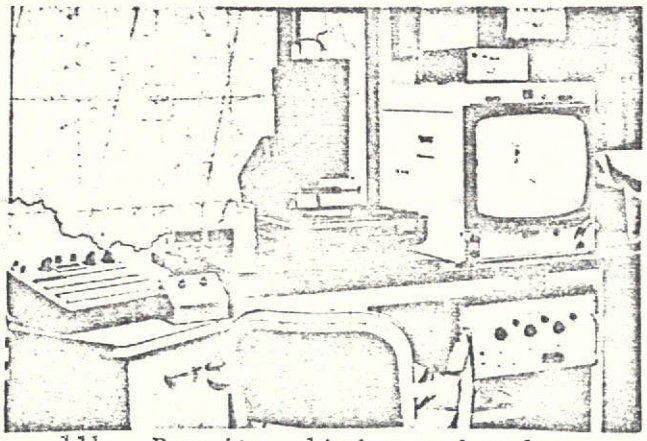
Effective land use planning holds the key to better solving contemporary land use related problems such as unplanned growth, land misuse, and deteriorating environmental quality. As a perceptive vehicle, multispectral and multidate remotely sensed ERTS data provide a more nearly real-time insight as to what are the discernible patterns of land use as well as the ways in which they are changing. Clearly, ERTS satellites are capable of providing the data necessary for comprehensive and operational mapping, surveying, and inventorying of terrestrial natural and cultural features; for the systematic detection of environmental hazards; and, for new interdisciplinary legislative, planning, policy formulating, and management concepts that will formulate the basis of future land use decisions in Ohio.

17

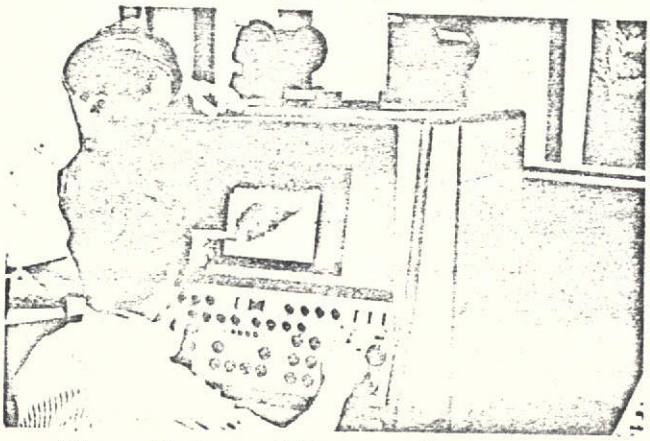
REMOTE SENSING AT BATTELLE COLUMBUS LABORATORIES



11a. ISCO Spatial radiometer used for spectral "signature" collection in the field.



11b. Density slicing and color encoding analysis system.



11c. Color additive viewer for image enhancement and comparison.

Battelle's Remote Sensing Applications Laboratory was established in direct response to increasing requirements for the effective and timely acquisition and analysis of remotely-sensed data in a number of disciplines and applications areas principally involving:

- Environmental Quality
- Agriculture
- Forestry
- Geography/Land Use
- Transportation
- Ecology.

The most prominent application of the laboratory has been to evaluate satellite imagery for its utility to the management of natural and cultural resources in the State of Ohio, involving an area of 40,000 square miles.

The laboratory is equipped with state-of-the-art image acquisition and analysis devices to perform in-depth research involving all aspects of remote sensing, with emphasis on multiband imagery.

One of the most important aspects of the laboratory which originally governed its design is its accessibility and visibility to a wide spectrum of researchers and planners within and outside the state. The equipment and analysis procedures have been chosen to permit users with little or no experience in remote sensing to gain appreciation and confidence for applying this new tool in their research and decision making functions.

Figure 11. State-of-the-Art Image Acquisition and Analysis Instruments for Remote Sensing Research at Battelle Columbus Laboratories.